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UNITED STATES
DEPARTMENT OF THE INTERIOR
HAROLD L. ICKES, SECRETARY

BUREAU OF MINES
JOHN W. FINCH, DIRECTOR

INFORMATION CIRCULAR

COAL-MINE EXPLOSIONS AND COAL- AND METAL-MINE FIRES IN THE UNITED STATES DURING THE FISCAL YEAR ENDED JUNE 30, 1939

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D. HARRINGTON AND W. J. FENE

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UNITED STATES DEPARTMENT OF THE INTERIOR - BUREAU OF MINES

COAL-MINE EXPLOSIONS AND COAL- AND METAL-MINE FIRES IN THE UNITED STATES DURING THE FISCAL YEAR ENDED JUNE 30, 1939[1]

By D. Harrington[2] and W. J. Fene[3]

INTRODUCTION

For nearly 30 years the Bureau of Mines has contended that mine explosions can be prevented and has pointed out to the industry ways and means by which they could be avoided. The record of coal-mine explosions during the past fiscal year bears out the Bureau's contention, inasmuch as fewer men were killed by coal-mine explosions in the United States during that year than in any corresponding 12 months in the history of coal mining in the United States, insofar as records are available; and more than a year has elapsed since a major explosion (in which five or more men were killed) has occurred, this being the first continuous 12-month period without a major coal-mine explosion disaster in the United States in more than 60 years.

The methods of preventing mine explosions are well known to experienced, well-informed persons engaged in coal mining. Despite this knowledge, many coal-mine operators continue to use practices and methods that they should know have resulted in countless explosions, and mine workers persist in following past procedure or in breaking safety rules and practices almost certain eventually to result in disaster.

Virtually all explosions are the result of human failure, such as carelessness or neglect by officials or workers or others. These human failures can be corrected chiefly by education and proper and adequate supervision and strict discipline. In some instances mine officials are lax, careless, poorly informed, and often incompetent; and in many instances miners have repulsed the introduction of known preventive methods because of sheer obstinacy, ignorance, heedlessness, or possibly fear that the operator was trying to obtain some unfair advantage or would neglect some other phase of accident or explosion prevention.

The freedom of the fiscal year 1938-39 from major coal-mine explosions and from any considerable number of fatalities from minor explosions is a matter for congratulation, but on the other hand the occurrence of one rather bad explosion in each of the 3 calendar years 1937,

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[1] The Bureau of Mines will welcome reprinting of this paper, provided the following footnote acknowledgment is used: "Reprinted from Bureau of Mines Information Circular 7092."

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1938, and 1939 indicates that at least some of our mining people have forgotten the lessons of the past; possibly the members of the younger generation now operating our coal mines are not as well informed about disaster causation as were their predecessors, who functioned in the old days when mine disasters occurred far more frequently than now. It would appear that additional educational work should be carried on to acquaint these newcomers with hazards about which the old-timers became well informed through bitter experience.

SUMMARY OF MINE EXPLOSIONS, BY STATES AND CAUSES

Table 1 summarizes essential data on the 14 explosions known to have occurred in eight States and resulting in 16 deaths during the fiscal year ended June 30, 1939. This table includes information on all coal-mine explosions in the United States brought to the attention of the Bureau of Mines during the fiscal year, and is believed to include information on every explosion in which life was lost or considerable damage resulted. The 14 explosions that occurred during the year were 15 fewer than the number known to have occurred during the previous year, and the number of deaths (16) was 154 fewer than in the previous year, when 170 fatalities were chargeable to coal-mine explosions.

The greatest number of deaths from explosions during the fiscal year 1938-39 occurred in West Virginia, with six; Virginia had four, Pennsylvani three, and Illinois, Kentucky, and Oklahoma one each. West Virginia had four explosions, Pennsylvania three, Washington two, and Alabama, Illinois, Kentucky, Oklahoma, and Virginia one each.

No major explosions occurred during the year; during 1938 there were eight major explosions with 146 deaths, and during 1937 there were five major explosions with 47 deaths. Six of the explosions that occurred during the year did not result in fatalities. Only one explosion is known to have occurred in Pennsylvania anthracite mines, and no fatalities resulted; hence the anthracite mines of Pennsylvania, employing around 100,000 persons and producing 40,000,000 to 50,000,000 tons of coal from mines, many of which are extremely gassy, had the remarkably good record of operating an entire year without a single fatality from gas ignitions.

Table 2 summarizes the causes of explosions that occurred during the fiscal years 1929 to 1939. It shows that 13 persons were killed during the past fiscal year in explosions initiated by electricity compared with 24 deaths the previous year and an average of 57 deaths per year for the preceding 10 years. Deaths from explosions due to electricity decreased nearly 50 percent compared with the previous fiscal year and more than 75 percent when compared to the average of the previous 10 years. There were explosions of electrical origin during 1939, compared with 10 such explosions in the previous year and an average of 11 for the previous 10 yea West Virginia had four explosions caused by electricity, with six deaths; Virginia, one with four deaths; Pennsylvania, two with two deaths; and Alabama and Illinois, one each, with a total of one death.

State	Lighting used			Fatalities by ignition causes									
	Open	Closed	Unknown	Electricity		Open lights or smoking		Explosives		Miscellaneous or unknown		Total	
				Deaths	Ignitions	Deaths	Ignitions	Deaths	Ignitions	Deaths	Ignitions	Deaths	Ignitions
Alabama.........	-	1	-	-	1	-	-	-	-	-	-	-	1
Illinois........	-	1	-	1	1	-	-	-	-	-	-	1	1
Kentucky........	-	1	-	-	-	-	-	-	-	1	1	1	1
Oklahoma........	1	-	-	-	-	1	1	-	-	-	-	1	1
Pennsylvania....	-	3	-	2	2	1	1	-	-	-	-	3	3
Virginia........	-	1	-	4	1	-	-	-	-	-	-	4	1
Washington......	1	1	-	-	-	-	1	-	-	-	1	-	2
West Virginia...	-	4	-	6	4	-	-	-	-	-	-	6	4
Total......	2	12	-	13	9	2	3	-	-	1	2	16	14

[1] Includes data on all coal-mine explosions in the United States insofar as could be ascertained by the Safety Division of the Bureau of Mines.

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TABLE 2. - Summary of data on explosions by causes, fiscal years 1929-39[1/]

	Lighting used			Fatalities by ignition causes									
	Open	Closed	Unknown	Electricity		Open lights or smoking		Explosives		Miscellaneous or unknown		Total	
				Deaths	Ignitions	Deaths	Ignitions	Deaths	Ignitions	Deaths	Ignitions	Deaths	Ignitions
1929..........	18	19	1	93	18	14	11	26	8	6	1	139	38
1930..........	8	25	1	154	18	21	8	24	6	-	2	199	34
1931..........	12	14	-	143	9	56	11	18	6	-	-	217	26
1932..........	15	14	4	11	10	33	15	42	5	1	3	87	33
1933..........	7	14	1	25	8	63	8	29	4	5	2	122	22
1934..........	9	14	3	21	10	2	9	2	3	3	4	28	26
1935..........	6	17	-	29	10	6	9	3	2	16	2	54	23
1936..........	15	9	1	20	5	10	17	4	1	4	2	38	25
1937..........	4	12	4	53	12	3	5	-	1	6	2	62	20
1938..........	10	16	3	24	10	77	11	61	6	8	2	170	29
1939..........	2	12	-	13	9	2	3	-	-	1	2	16	14
Total	106	166	18	586	119	287	107	209	42	50	22	1132	290

[1/] The fiscal year ends June 30.

During the fiscal year 1939, 3 explosions were caused by open lights and smoking compared with 11 during the preceding year and an average of 10.4 during the previous 10 years. Only 2 deaths were due to explosions caused by open lights or smoking last year compared with 77 deaths from this cause during the previous fiscal year and an average of 28.5 during the previous 10 years. Explosions caused by open lights or smoking occurred in Oklahoma, Pennsylvania, and Washington, with a total of two deaths. In one of these a fireboss ignited gas with a carbide lamp, which caused his death; in another instance, in a closed-light mine, a miner was killed when he ignited gas with a match when he attempted to smoke; both of these were examples of flagrant, one might almost say criminal, carelessness and negligence involving a supervisory official in one and a workman in the other.

No explosions are known to have been due to explosives during the past fiscal year compared with 6 explosions and 61 deaths from this cause during the previous year and an average of 4.2 explosions and 20.9 deaths during the previous 10 years. Working the coal mines of the United States an entire fiscal year without a mine explosion caused by explosives is a remarkably fine record, but it would be misleading in the extreme to infer that all hazards of explosions due to explosives have been removed from our coal mines. The unfortunate fact is that the three coal-mine-explosion disasters with maximum number of fatalities per disaster (34, 45, and 28) in the past 7 calendar years (1933 to and including July 1939) have been caused by blasting during the working shift, and in all three instances the explosive in use was the safest known type, namely, permissible explosive. Unquestionably, blasting in coal mines continues to be hazardous, and it is particularly dangerous when done with the working shift in the mines.

Two explosions from miscellaneous or unknown causes resulted in one death. One of these explosions is reported to have occurred when gas was ignited in the undercut by the bits of a mining machine; the other is reported to have been caused by a defective flame safety lamp.

RECORD OF EXPLOSIONS, BY STATES

Table 3 shows the record of explosions, by States, during the past 11 fiscal years. During this 11-year period, 290 explosions caused 1,132 deaths, an average of 102.8 deaths and 26.4 explosions per year; hence, the number of explosions (14) and deaths (16) was much less than the average for the 11 years. For the 11-year period, Pennsylvania leads in the total number of explosions (86) and the largest number of deaths (220); West Virginia is next, with 54 explosions and 153 deaths; and Virginia, with only 14 explosions, had the next largest number of deaths (128). It is interesting to note that during the 11-year period Kansas and Maryland had one explosion each, with a total of three deaths; Tennessee had four explosions without a fatality in the 11 years; Alaska had experienced its first explosion during 1938; Kansas has not had an explosion during the past 10 years; and Utah has not had an explosion for the past 9 years.

TABLE 3. - Record of explosions, by States, during fiscal years 1929-39[1]

State	1929		1930		1931		1932		1933		1934		1935		1936		1937		1938		1939		Total 11 years		Average per year		
	Deaths	Igni-tions	Deaths	Igni-tions	Deaths	Igni-tions	Deaths	Igni-tions	Deaths	Igni-tions	Deaths	Igni-tions	Deaths	Igni-tions	Deaths	Igni-tions	Deaths	Igni-tions	Deaths	Igni-tions	Deaths	Igni-tions	Deaths	Igni-tions	Deaths	Igni-tions	Average deaths per ig-nition
Alabama......	13	7	8	4	-	2	4	5	-	-	2	2	-	1	-	1	-	-	37	2	-	1	64	25	5.8	2.3	2.55
Alaska.......	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	14	1	-	-	14	1	1.3	.09	14.00
Arkansas.....	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	5	1	4	4	-	-	9	5	.8	.4	1.80
California...	-	1	7	2	12	1	-	1	-	1	-	-	-	-	-	-	-	-	-	-	-	-	19	6	1.7	.5	3.17
Colorado.....	-	-	-	1	-	-	4	3	1	1	-	-	-	-	12	2	1	1	-	-	-	-	18	8	1.6	.7	2.25
Illinois.....	-	3	10	2	2	1	3	3	54	1	-	-	-	-	-	-	-	-	5	2	1	1	75	13	6.8	1.2	5.77
Indiana......	-	-	-	-	28	1	-	-	4	2	-	-	-	-	2	3	-	-	22	2	-	-	56	8	5.1	.7	7.00
Kansas.......	2	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	1	.2	.09	2.00
Kentucky.....	11	3	16	1	-	-	3	1	26	2	-	1	1	1	9	1	-	-	-	2	1	1	67	13	6.1	1.2	5.50
Maryland.....	-	-	-	-	-	-	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1	.09	.09	1.00
New Mexico...	-	-	-	-	8	3	-	-	14	1	-	-	-	-	-	-	-	-	-	-	-	-	22	4	2.00	.4	5.50
Ohio.........	3	3	1	2	88	3	-	-	-	-	-	-	-	-	4	1	-	-	2	1	-	-	98	10	8.9	.9	9.80
Oklahoma.....	1	1	71	4	45	2	-	-	3	2	-	-	3	2	-	-	3	1	-	-	1	1	127	13	11.5	1.2	9.80
Pennsylvania.	70	9	16	8	23	7	7	6	9	6	16	14	24	11	8	10	14	5	30	7	3	3	220	86	20.0	8.3	2.41
Tennessee....	-	-	-	-	-	-	-	3	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	4	.0	.4	-
Utah.........	1	2	30	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	31	5	2.8	.5	6.20
Virginia.....	2	1	-	-	-	-	54	3	-	-	2	3	18	2	-	-	2	1	46	3	4	1	128	14	11.6	1.2	9.14
Washington...	-	-	17	2	-	2	-	-	2	1	-	2	-	-	-	4	1	2	-	1	-	2	20	16	1.8	1.4	1.25
W. Virginia..	36	7	23	5	11	4	11	7	9	5	8	4	5	4	3	3	36	8	5	3	6	4	153	54	13.9	4.9	2.83
Wyoming......	-	-	-	-	-	-	-	-	-	-	-	-	3	1	-	-	-	-	5	1	-	-	8	2	.7	.18	4.00
Total...	139	38	199	34	217	26	87	33	122	22	28	26	54	22	38	25	62	20	170	29	16	14	1,132	290	102.8	26.4	3.90

[1] The fiscal year ends June 30.

The average number of deaths per explosion during the past 11 years is 3.90, with a range for the various States from none to 14 deaths per explosion. States with the most deaths per explosion during the past 11 years are Alaska (14), there having been only one explosion involved; Ohio and Oklahoma, 9.80 each; and Virginia, 9.14. It is noteworthy that in these three States relatively little attention has been given to rock-dusting or to the use of closed lights and to precautions with electrical equipment. The following coal-producing States are not listed in table 3, as they are not known to have had an explosion during the past 11 years: Iowa, Michigan, Missouri, Montana, North Dakota, and Texas.

CAUSES OF EXPLOSIONS

Table 4 gives data on causes of explosions in the United States during the past 11 years, as reported to the Safety Division of the Bureau of Mines by its field representatives. In all, 290 explosions have been studied during the 11-year period, an average of 26.4 explosions per year. There were 14 explosions during the past fiscal year, which is 15 fewer than during the previous year and 12.4 fewer than the average for the past 11 years.

Table 4 shows that for the 11-year period electricity was responsible for 119 (41.0 percent) and open lights and smoking for 107 (37.0 percent) of the explosions listed; hence, 78 percent of all known explosions during this 11-year period were started by ignitions due to electricity, open lights, and smoking.

The number of explosions of electrical origin during the past year (9) is slightly less than the average of the preceding 10 years, while the number caused by open lights or smoking (3) is considerably less than the average (9.7) from those causes during the previous 10 years.

Table 4 shows that no explosions were caused by explosives during the past year compared with 6 such explosions during the previous year and an average of 4.2 during the previous 10 years. This favorable reduction in explosions caused by explosives during the past 11 years, excluding 1938, may be attributed chiefly to the increased use of permissible explosives, to increase in safe practices of handling explosives, to improved ventilation, and to more intensive supervision. However, as previously indicated in this report, it should not be inferred that freedom from explosions due to blasting during last year (fiscal) indicates that there is no longer any hazard due to blasting in coal mines; a coal-mine disaster with 34 deaths occurred in 1937 due to blasting, one with 45 deaths occurred in 1938 due to blasting, and one occurred in July 1939 with 28 deaths due to blasting, and all three of these disasters took place on night shifts and in highly mechanized mines.

Of the two explosions listed under unknown or miscellaneous causes, one was caused by an ignition of gas by a defective flame safety lamp; following this explosion the company examined and tested all of its flame safety lamps and found many of them to be defective. In the other explosion listed under this cause, a machineman was killed when gas was ignited in the undercut, presumably by sparks from the cutter bits, though there is some question as to the accuracy of this deduction.

TABLE 4. - Comparison of explosions by ignition causes, fiscal years 1929-39, inclusive

Year	Ignition by electricity		Ignition by open lights or smoking		Ignition by explosives		Ignition due to unknown or miscellaneous causes		Total	
	Number	Percent	Number	Percent	Number	Percent	Number	Percent	Number	Percent
1929..........	18	47.4	11	29.0	8	21.0	1	2.6	38	100
1930..........	18	52.9	8	23.5	6	17.6	2	6.0	34	100
1931..........	9	34.6	11	42.3	6	23.1	-	-	26	100
1932..........	10	30.3	15	45.5	5	15.1	3	9.1	33	100
1933..........	8	36.4	8	36.4	4	18.1	2	9.1	22	100
1934..........	10	38.5	9	34.6	3	11.5	4	15.4	26	100
1935..........	10	43.5	9	39.1	2	8.7	2	8.7	23	100
1936..........	5	20.0	17	68.0	1	4.0	2	8.0	25	100
1937..........	12	60.0	5	25.0	1	5.0	2	10.0	20	100
1938..........	10	34.5	11	37.9	6	20.7	2	6.9	29	100
1939..........	9	64.3	3	21.4	-	-	2	14.3	14	100
Total.......	119	41.0	107	37.0	42	14.4	22	7.6	290	100
Average.....	10.8	41.0	9.7	37.0	3.8	14.4	2.0	7.6	26.4	100

EXPLOSION FATALITIES, BY CAUSES

Table 5 compares explosion fatalities by causes and shows that during the past 11 years 1,132 fatalities resulted from explosions in mines in the United States, an average of 102.9 per year. The record of explosion fatalities during the fiscal year 1939, none from major and 16 from minor explosions, is by far the best since records have been available; in fact, as already stated, the record for the fiscal year 1939 is much better than any recorded continuous 12-month period in at least 60 years.

Explosions of electrical origin were responsible for 13, or 81.3 percent, of the deaths from explosions during the past year; this is a marked decrease in the number of fatalities from this type of explosion cause compared with the average of 57.3 for the preceding 10 years. In view of the rapid increase in use of underground electrical equipment during the past several years, much of it placed at the face region where the maximum hazard exists, the record for the past 2 years has been distinctly favorable; however, virtually all of the explosions of electrical origin that have occurred not only in the past 2 years but previously, and the fatalities from them probably could have been avoided if readily available, efficient permissible equipment had been used. With rapid extension of mechanized mining using electrical equipment, the very least that should be done in the cause of safety is to use only the safest available types, and this means permissible equipment.

Open lights and smoking caused explosions that resulted in two deaths, or 12.5 percent of all fatalities due to explosions during the past fiscal year; this is a substantial decrease in the number of fatalities from these causes compared with 77 deaths during 1938 and an average of 28.5 deaths per year during the previous 10 years. In one of these explosions, a fireboss making a preshift inspection with a carbide lamp and a Baby Wolf flame safety lamp ignited gas with his open light, which caused his death; no careful, competent fireboss would use an open light in any coal mine at any time or for any purpose. In another explosion a miner lost his life when he ignited gas by a lighted match when he attempted to smoke; this is a far too usual type of man-failure in our coal mines and one very difficult to prevent. Apparently some of our firebosses and many of our mine workers have not learned to give proper respect to the hazard of gas; however, mine management is primarily responsible for the first-mentioned type of explosion because no fireboss should be allowed to use an open light during his inspection; and it certainly is the height of inconsistency for a fireboss to carry an open light when testing for gas; it is as criminally foolish as hunting for a leak in a gas line with a lighted match.

During the past 11 years, 209 deaths (18.4 percent of all deaths due to explosions during this period) resulted from explosions caused by use of explosives. The record of explosions caused directly by explosives during 5 of the past 6 years has been more than ordinarily good, as there were seven explosions with only nine deaths caused directly by explosions started by explosives, though there were numerous other fatalities due to explosions caused by conditions brought about by blasting during the working shift; during 1 year (1938) there were 6 explosions and 61 deaths from explosions caused directly by blasting, and 34 others caused by an ignition of gas immediately after it was released by blasting. Moreover, there was an explosion due to blasting after June 30 in 1939 in which 28 lives were lost.

TABLE 5. - Comparison of explosion fatalities by ignition causes, fiscal years 1929-39, inclusive

Year	Electricity		Open lights or smoking		Explosives		Unknown or miscellaneous causes		Total	
	Number killed	Per-cent	Number killed	Per-cent	Number killed	Per-cent	Number killed	Per-cent	Number killed	Per-cent
1929............	93	66.9	14	10.1	26	18.7	6	4.3	139	100
1930............	154	77.4	21	10.5	24	12.1	-	-	199	100
1931............	143	65.9	56	25.8	18	8.3	-	-	217	100
1932............	11	12.7	33	37.9	42	48.3	1	1.1	87	100
1933............	25	20.5	63	51.6	29	23.8	5	4.1	122	100
1934............	21	75.0	2	7.1	2	7.1	3	10.8	28	100
1935............	29	53.7	6	11.1	3	5.6	16	29.6	54	100
1936............	20	52.6	10	26.4	4	10.55	4	10.55	38	100
1937............	53	85.5	3	4.8	-	-	6	9.7	62	100
1938............	24	14.1	77	45.3	61	35.9	8	4.7	170	100
1939............	13	81.3	2	12.5	-	-	1	6.2	16	100
Total.........	586	51.8	287	25.4	209	18.4	50	4.4	1,132	100
Average.......	54.2	51.8	26.1	25.4	19.0	18.4	4.5	4.4	102.9	100

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Regardless of contributory factors, the policies regarding the use of explosives are formulated chiefly by mine operators; hence, it is largely their responsibility to prevent accidents and explosions due to explosives.

During the past 11 years 50 persons were killed in mines in the United States in 22 explosions due to miscellaneous or unknown causes. During the past fiscal year two explosions, causing one death, were listed under this classification. Less than 5 percent of the explosions that occurred during the past 11 years have been listed as miscellaneous or from unknown causes, which is remarkably low when it is considered that it is often difficult, sometimes impossible, to determine definitely the cause of an explosion.

ELECTRICAL CAUSES OF EXPLOSIONS

Table 6 gives data available to the Bureau of Mines relating to details of the causes of explosions of electrical origin in the United States during the past 11 years. During this period there were 119 explosions of electric origin, 9 of which, with 13 deaths, occurred during the past fiscal year.

The greatest sources of explosions attributed to electricity in coal mines are trolley or cable-reel locomotives and nonpermissible mining machines, which jointly were responsible for about half of the electrical explosions during the 11-year period and for one-third of the electrical explosions that occurred during the past year.

In most of the electrical ignitions during the past 11 years there has been evidence of carelessness or flagrant disregard of safe ventilation practices, such as doors left open (generally latched open) on main or important haulage entries, line brattices in poor condition or not extended close enough to the face, coursing air through or past partly caved more or less inaccessible and hence poorly ventilated workings, or other similar manifestations of neglect. Other factors concerned in these electrical ignitions were (1) failure to test for gas before going into working place with electrical equipment, such as mining machine, trolley locomotive, loading machine, or electric drill, or failure to test from time to time while using the equipment; (2) use of electrical equipment too soon after the mine fan has been started following a period of shut-down; (3) failure to examine a mine properly on idle days when only a skeleton crew is in the mine; (4) use of haulageways as return airways, a practice that always has been hazardous in the extreme, whether in gassy or so-called nongassy mines; and numerous other heedless or careless practices in connection with safe coal-mine procedures involving ventilation.

COMPARISON OF LIGHTING IN MINES WHERE EXPLOSIONS OCCURRED

Table 7 shows data as to methods of lighting in mines where explosions occurred during the past 11 years; of the 290 explosions that occurred during this period, 106 (36.6 percent) were in open-light mines; 166 (57.2 percent) were in closed-light mines; and 18, or 6.2 percent, were in mines in which the lighting practice was unknown. During the past fiscal year, 2 (14.3 percent) of the explosions occurred in open-light mines compared to an average of 10.4 explosions per year in open-light mines during the preceding 10 years.

TABLE 6. - Electrical causes of explosions, fiscal years 1929-39, inclusive

Cause	Number of electrical explosions, by fiscal years											Total, 11 years	Number killed	
	1929	1930	1931	1932	1933	1934	1935	1936	1937	1938	1939		1938	1939
Trolley or cable-reel locomotive	1/ 5	5	1	1	4	5	3	1	5	4	3	36	16	7
Nonpermissible mining machine...	2/ 5	5	3	3	1	-	2	1	3	3	-	25	5	-
Nonpermissible electric motor...	4	3	-	-	-	-	2	-	-	1	2	12	2	4
Nonpermissible shot-firing battery or circuit..............	-	3/ 2	3/ 3	1	-	1	-	-	-	-	-	2	-	-
Cable nips or cable blow-out....	-	2	-	-	-	1	-	-	1	-	1	5	-	-
Nonpermissible electric drill...	-	-	-	2	-	1	2	-	-	-	2	7	-	-
Nonpermissible storage-battery locomotive..................	1	1	2	-	-	-	-	-	-	-	-	4	-	-
Nonpermissible electric hoist...	-	-	-	-	1	-	-	-	-	-	-	1	-	-
Faulty wiring..................	2	2	-	-	-	-	-	1	1	-	-	6	-	-
Trolley wire...................	1	-	2	1	-	-	-	1	-	-	-	5	-	-
Electric arc...................	2	-	1	2	1	2	1	4/ 1	1	2	1	14	1	2
Signal wire....................	-	-	-	-	1	-	-	-	1	-	-	2	-	-
Total......................	18	18	9	10	8	10	10	5	12	10	9	119	24	13

1/ 1 not included in total; may have been from open light.
2/ 1 not included in total; may have been from smoking.
3/ Not included in total; may have been from overcharged shot.
4/ Included, but may have been from smoking.

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Fiscal years 1929-39, inclusive

Year	Open lights		Closed lights		Lighting unknown		Total	
	Number of explosions	Per-cent	Number of explosions	Per-cent	Number of explosions	Per-cent	Number of explosions	Per-cent
1929	18	47.4	19	50.0	1	2.6	38	100
1930	8	23.5	25	23.5	1	3.0	34	100
1931	12	46.2	14	53.8	-	-	26	100
1932	15	45.5	14	42.4	4	12.1	33	100
1933	7	31.8	14	63.6	1	4.6	22	100
1934	9	34.6	14	53.7	3	11.5	26	100
1935	6	26.1	17	73.9	-	-	23	100
1936	15	60.0	9	36.0	1	4.0	25	100
1937	4	20.0	12	60.0	4	20.0	20	100
1938	10	34.5	16	55.2	3	10.3	29	100
1939	2	14.3	12	85.7	-	-	14	100
Total	106	36.6	166	57.2	18	6.2	290	100

The fact that during the past fiscal year 85.7 percent of the explosion occurred in closed-light mines and that during the past 11 years 57.2 percen of all explosions occurred in mines using closed lights may be interpreted in several ways. Probably the most nearly correct explanation is that in many States the most gassy, hence the most dangerous, mines use closed ligh No explosion is known ever to have been caused by an electric cap lamp; this indicates that very probably there has been carelessness in connection with other explosion-prevention methods and practices, and this certainly is true in at least some closed-light mines, otherwise explosions would not have occurred in closed-light mines. In many mines where closed lights are adopted undue dependence is thereafter placed on the lamps, with more or less open neglect of ventilation and other precautionary measures; this shows a flagra violation of sane mining and is absolutely indefensible. The use of the up-to-date permissible electric cap lamp is unquestionably one of the most effective means now known for forwarding safety in mining (coal or metal), and any agency or influence that fails to use or tries to prevent the use of electric cap lamps in underground mines is either woefully ignorant of mine safety requirements or is deliberately callous to the demands of humanitari operation of mines. An organization or influence that neglects other essential safety procedures through undue reliance on electric cap lamps shou not be allowed to have any connection with mines or mining.

EXPLOSIONS IN BITUMINOUS-COAL MINES

Figure 1 gives illuminating information about the fatalities resulting from gas and dust explosions in bituminous-coal mines of the United States during the calendar years 1906 to 1938, inclusive. The trend of explosion fatalities was downward from 1907 to 1921, with a marked rise from 1922 to 1924 and a definite, fairly steady, downward trend from 1924 to 1935; however, the trend has been upward during the past 3 years, especially 1937 an 1938. It is significant that every alternate year during the period 1924 t 1936 has shown an increase in the number killed over the preceding year, al though the general trend has been downward. A plausible explanation is tha a year with a relatively low explosion-fatality record results in relaxati of accident-prevention efforts during the following year and, conversely, a high explosion-fatality record acts as a spur toward taking precautionary measures. The tabulation on the graph showing average annual fatalities from bituminous-coal-mine explosions over 5-year periods from 1906-1910 to 1931-1935 is illuminating, showing, as it does, a heavy and fairly steady decrease in annual fatalities from 438 for the 5-year period 1906-10 to 65 for the 5-year period 1931-35, a decrease of 85.5 percent. The significan of this is seen from the fact that if the rate of explosion fatalities for the 5-year period 1906-10 (438 per year) had continued through 1935, 13,14 lives would have been lost from this cause instead of 7,800 (the approximat number actually lost). If the rate of occurrence of such accidents in the 5-year period 1931-35 (65 per year) had been in effect from 1906 to the en of 1935, the total would have been only 1,950 instead of the approximately 7,800 that actually were killed. Additional significance attaches to the fact that during the past 5 years 1934-38, inclusive, the fatalities from

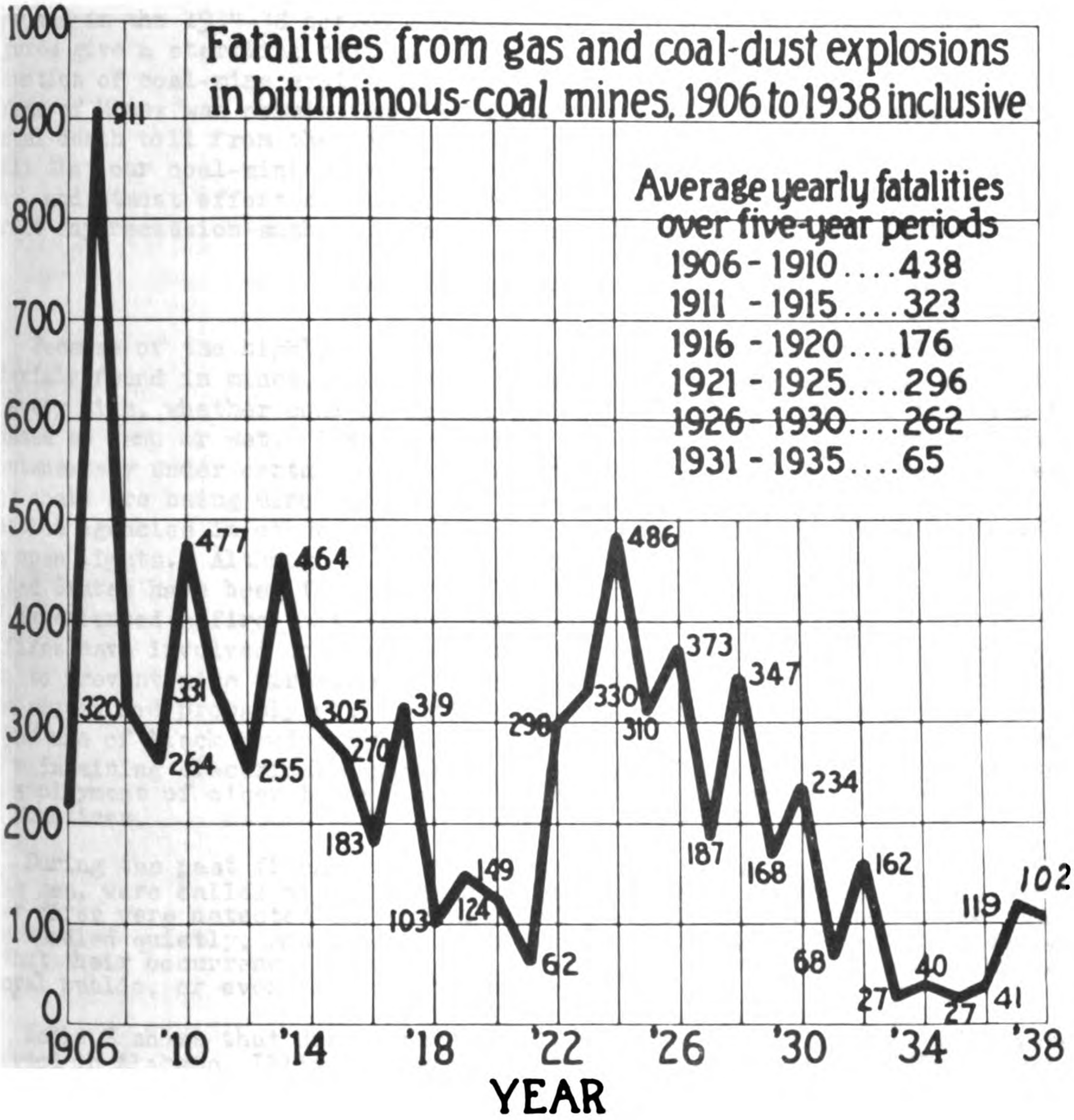
Fatalities from gas and coal-dust explosions in bituminous-coal mines, 1906 to 1938 inclusive
Average yearly fatalities over five-year periods
1906 - 1910....438
1911 - 1915....323
1916 - 1920....176
1921 - 1925....296
1926 - 1930....262
1931 - 1935....65
FATALITIES
1000
900
800
700
600
500
400
300
200
100
0
1906
'10
'14
'18
'22
'26
'30
'34
'38
YEAR
911
320
331
477
264
255
464
305
270
183
319
103
149
124
62
298
330
486
310
373
187
347
168
234
68
162
27
40
27
41
119
102

Figure 1.

coal-mine explosions in the United States averaged but 65 per year; if this is compared with the average of 438 fatalities annually for the 5-year period, 1906-10, inclusive, the reduction is 85.1 percent. In other words, where 100 persons were being killed by coal-mine explosions during the period 1906-10, only 14.9 have been so killed during the past 5 years. The production of coal in the 1906-10 period was at the rate of about 451,000,000 tons per year and in the 1934-38 period about 443,000,000 tons per year. These figures give a startling picture of the progress that has been made in the reduction of coal-mine explosion fatalities in the United States since the Bureau of Mines was commissioned by Congress in 1910 to try to reduce the annual death toll from that cause. No sane, fair-minded person can fail to dmit that our coal-mining people have done a good job in explosion preven-tion, and utmost effort should be made to maintain the good record and not ermit any recession such as appears to have begun in 1937 and 1938.

MINE FIRES

Because of the highly combustible nature of coal, timber, and other aterials found in mines, the potential hazard of a fire is always present n every mine, whether coal or metal, and this is true even when the mine is lassed as damp or wet. Some coals and other materials used in mines ignite pontaneously under certain conditions, creating a very serious hazard where uch coals are being mined or such materials used; but the most prolific gnition agencies in connection with mine fires are electricity, explosives, nd open lights. Although fire hazards are ever present the mines of the nited States have been fortunate during the past decade in that they have ot experienced a fire that caused large loss of life; however, a number f fires have involved considerable property damage. Although much can be one to prevent mine fires, some companies employ methods or equipment that ave caused and probably will continue to cause fires in their mines, such s the use of black powder and fuse, slipshod methods of installing, using, nd maintaining electrical equipment, use of open lights, permitting smoking, nd employment of other loose, unsafe, or out-of-date mining apparatus, methods, nd practices.

During the past fiscal year, 20 fires, which resulted in the death of hree men, were called to the attention of the Bureau of Mines. Scores of ther fires were detected and extinguished promptly without much damage, or ere handled quietly, and in some instances more or less by the mine involved, o that their occurrence was not made known to the Bureau of Mines, the eneral public, or even to State inspection forces.

Table 8 shows that during the past fiscal year two mine fires each were eported in Alabama, Illinois, Kentucky, Ohio, Pennsylvania, and West Virginia, nd one each in Arizona, Alaska, California, Idaho, Indiana, Michigan, Tennessee, nd Washington. Of the 20 fires, 1 was in an anthracite mine, 3 were in metal ines, and 2 were outcrop fires, the others being in bituminous-coal mines. ree fatalities resulted from the 20 fires; in one instance two men were as-yxiated underground by gases from a fire in the tipple. Electricity was he cause of eight of the fires, an open light caused one, and explosives aused three. Of the eight fires listed under unknown or miscellaneous auses, two were probably caused by spontaneous combustion and six were of nknown origin. The 20 fires reported to the Bureau of Mines during the iscal year 1939 are three fewer than the average for the preceding 9 years, nd the deaths resulting from fires during the past year (3) were about 62 ercent less than the average for this period.

TABLE 8. - Summary of mine fires, by States, fiscal year 1939 and 1930-38, inclusive

State	Lighting used			Fatalities by ignition cause									
				Electricity		Open lights		Explosives		Unknown or miscellaneous		Total	
	Open	Closed	Unknown	Deaths	Fires	Deaths	Fires	Deaths	Fires	Deaths	Fires	Deaths	Fires
Alabama..........	-	2	-	-	2	-	-	-	-	-	-	-	2
Alaska...........	-	1	-	-	-	-	-	-	-	-	1	-	1
Arizona..........	1	-	-	-	-	-	1	-	-	-	-	-	1
California.......	1	-	-	-	1	-	-	-	-	-	-	-	1
Idaho............	1	-	-	-	1	-	-	-	-	-	-	-	1
Illinois.........	2	-	-	-	-	-	-	-	2	-	-	-	2
Indiana..........	1	-	-	1	1	-	-	-	-	-	-	1	1
Kentucky.........	-	2	-	-	2	-	-	-	-	-	-	-	2
Michigan.........	1	-	-	-	-	-	-	-	-	-	1	-	1
Ohio.............	1	-	1	-	-	-	-	-	-	2	2	2	2
Pennsylvania.....	-	2	-	-	1	-	-	-	-	-	1	-	2
Tennessee........	1	-	-	-	-	-	-	-	1	-	-	-	1
Washington.......	-	1	-	-	-	-	-	-	-	-	1	-	1
West Virginia....	-	1	1	-	-	-	-	-	-	-	2	-	2
Total, 1939...	9	9	2	1	8	-	1	-	3	2	8	3	1/ 20
1938............	7	6	13	1	7	2	2	-	1	5	14	8	2/ 24
1937............	7	4	10	9	5	-	-	-	3	2	13	11	3/ 21
1936............	16	4	3	1	7	-	2	-	3	3	11	4	4/ 23
1935............	7	5	14	11	11	-	1	-	-	-	14	11	5/ 26
1934............	10	5	3	-	4	-	-	5	5	1	9	6	18
1933............	12	6	9	-	7	-	-	-	2	2	18	2	27
1932............	8	5	8	1	8	-	-	-	3	-	10	1	21
1931............	12	7	5	-	7	5	3	-	5	18	9	23	24
1930............	7	8	9	2	9	3	6	-	3	-	6	5	24
Total, 10 years	95	59	76	26	72	10	15	5	28	28	114	74	228

1/ Includes 3 metal-mine fires. 2/ Includes 6 metal-mine fires. 3/ Includes 5 metal-mine fires.
4/ Includes 12 metal-mine fires and 2 outcrop fires. 5/ Includes 5 metal-mine fires and 4 outcrop fires.

SUMMARY

It is interesting to note that of the 25 major coal-mine-fire disasters, ith a total of 566 fatalities since 1900, only four (with 29 deaths) have ccurred since 1921; that no major coal-mine-fire disaster occurred in the nited States from 1926 to 1933, inclusive; and that one occurred in March 934 with five fatalities; one in May 1935 with six fatalities; and one in ugust 1936 with nine fatalities. The occurrence of three major mine-fire isasters during the 3 years 1934, 1935, and 1936, with a total of 20 deaths, ogether with the fact that none occurred in the preceding 8 years shows that roper precautions have not been taken in late years to prevent or handle ine fires; and in studying the circumstances connected with these three ires, there is no question but that improper procedure has been used in rotecting workers who are attempting to fight the fires, or those engaged in escue work, from poisonous or asphyxiating gases. This would indicate that ur mining people, through long immunity from harm to employees by mine fires, ither have become negligent or have forgotten much of their familiarilty ith the hazard of mine fires and of safe and efficient practices and methods f preventing them and of handling them when they do occur. Probably past essons learned through the medium of fires with heavy loss of life some ears ago have been forgotten; and undoubtedly many of the operating men of day, not having the benefit of tragic experience, really need education as necessary precautions in the safe methods of handling fires as well as preventing them from occurring.

The decrease in frequency and severity of explosions in the United States uring the past 30 years has been encouraging and indicates that efforts to event explosions have been largely successful. The record for the fiscal ar 1939 is the best in the history of coal mining since it became a major dustry. Although the record for 1937 and 1938 was not as favorable as it uld and should have been, as a whole that for the past 6 years has been ceptionally good, indicating that in spite of the rapid introduction of ectrical equipment with much added hazard during face operations, ad-tional precautionary measures are being taken to prevent explosions, the st important of these being involved in the more intensive supervision that n be given when mechanization is handled as it should be.

All of the 14 explosions that occurred during the past fiscal year iginated in ignitions of gas; in most of these ignitions it is definitely own that ventilation was not adequate or that the regular ventilation cir-it had been interrupted.

Salient points brought out by the Safety Division of the Bureau of Mines the study of explosions and fires in the United States during the fiscal ar ended June 30, 1939, are:

1. Fourteen explosions were studied, 13 in bituminous mines and 1 in anthracite mine, compared to 29 explosions in 1938 and an average of 27.6 the previous 10 years.

2. Explosions took 16 lives in the fiscal year 1939 compared with 170 in 1938 and an average of 111.6 in the previous 10 years. The 13 explosions in bituminous mines resulted in 16 deaths, while the 1 explosion in an anthracite mine resulted in 5 injuries and no deaths. Attention is directed to the fact that insofar as is known, the anthracite mines of the United States, employing about 100,000 persons and producing between 40,000,000 and 50,000,000 tons of coal, operated through the past fiscal year without a death caused by ignition of gas; this is a remarkably good record.

3. No major explosions occurred during the past fiscal year compared to eight major explosions during the previous fiscal year. In 6 of the 14 minor explosions known to have occurred there were no deaths. There was no major explosion in the bituminous mines of the United States from April 22, 1938, to July 14, 1939, or nearly 15 months, and there was no major explosi in anthracite mines from June 2, 1938, to September 1, 1939 (date of writin or 15 months. The operation of the 6,000 or more coal mines of the United States employing more than 500,000 men in the production of approximately 400,000,000 tons of coal for a full fiscal year without a major explosion disaster is an achievement in which the coal-mining industry can very well take pride. Although this is the first full 12-month period in more than 60 years without a major coal-mine explosion in the United States, there is good reason to believe that repetition of this good record or the establishment of a much better one will not wait nearly as long as 60 years.

4. Two of the explosions occurred in open-light mines compared with l in 1938 and an average of 10.4 in the previous 10 years. Twelve of the explosions were in closed-light mines compared with 16 in 1938 and an averag of 15.4 in the previous 10 years. As in preceding years, some of the explosions initiated in closed-light mines were by open flames (matches used by smokers or by defective flame safety lamps); the persistence of the nea criminal habit of smoking in closed-light mines is one of the most deplorab signs of the times, indicating as it does that many of our mine workers ar callous not only as to their own safety but also as to the safety of their fellow workers. The occurrence of explosions due to defective flame safet lamps or misuse of flame safety lamps indicates that they should be used b relatively few people, and then their use should be safeguarded by rigid restrictions.

5. Nine explosions, causing 13 deaths, were of electrical origin compared with 10 such explosions and 24 deaths in the previous fiscal year. Explosions of electrical origin averaged 11, with 57.3 deaths annually, fo the previous 10 years. Explosions of electrical origin are likely to incr unless our mining people take much more care than usual in the installatio and use of electrical equipment in the rapid extension of mechanized minin especially mechanized face loading. The very least that should be done in placing loading equipment at or near gassy and dusty faces is to make cert that only the safest available equipment is used, and that means permissib **electrical** equipment, where electricity is the motive power.

6. Open lights and smoking caused three explosions and two deaths in 1939 compared with 11 explosions and 77 deaths in 1938 and an average of 10.4 explosions and 28.5 deaths during the previous 10 years. The three explosions due to open lights and smoking in 1939 were in bituminous mines; one was caused when a fireboss ignited gas with a carbide lamp and another when a miner lighted a match in attempting to smoke.

7. No explosions were caused by explosives during the fiscal year 1939 compared with six explosions and 61 deaths in 1938 and an average of 4.2 explosions and 20.9 deaths from this cause during the previous 10 years.

8. Rock dust was used to some extent in at least seven mines in which explosions occurred during the past fiscal year. In most of these mines, rock-dusting is credited with being a factor in preventing the spread of the explosion.

9. All 14 of the explosions that occurred during the past fiscal year were initiated by gas. In almost all of these explosions it was indicated that the ventilating current had been interrupted and that in some instances inspection for gas had not been adequate. Evidently ventilation practice is not as efficient in many of our mines as it should and could be. Very often there is at present neglect of ventilation, with undue reliance placed on electric cap lamps, permissible explosives, rock dusting, and other installations and practices that require less continuous personal attention and effort by operating officials than does ventilation.

10. The severity and frequency of explosions last year exhibited a marked decrease compared to the average for the preceding 10 fiscal years. The average number of deaths per explosion last year was 1.14 compared to an average of 5.9 in 1938 and an average of 4.04 during the preceding 10 years. No fatalities resulted from six of the explosions that occurred during the last fiscal year.

11. The 16 deaths caused by explosions during the past fiscal year occurred in six States; 20 of the coal-producing States as well as anthracite mining in Pennsylvania had no fatalities from explosions so far as known.

12. During the fiscal year 1939, 20 fires (including 3 in metal mines) with three deaths were reported compared with 24 fires and eight deaths in 1938, and an average of 23 fires and eight deaths for the preceding 9 years.

13. Eight of the fires in the past fiscal year were of electrical origin, one was caused by a carbide lamp, three were caused by explosives, two were of spontaneous origin, and six were of miscellaneous or unknown origin.

14. The frequency of mine fires has shown no appreciable reduction during the past decade, and this should act as a warning to our mining people, even though fatalities from fires have decreased in recent years. The potential hazard of fires in any mine is always serious, especially in coal mines, as they may precipitate explosions. Every underground mine has a

fire hazard; this should be recognized and plans made and kept in operation to handle fire situations quickly and safely if or when fire occurs.

CONCLUSIONS

This circular was compiled in essentially the same manner as were those of previous years (see Information Circulars 6178, 6419, 6540, 6680, 6761, 6819, 6870, 6927, 6986, and 7048) and embodies only facts revealed through studies by field employees of the Safety Division of the Bureau of Mines. The Bureau of Mines attempts to obtain information concerning every explosion and most fires that occur in the mines of the United States, but some of the less destructive may not have been brought to its attention earl enough to permit investigation. However, the Bureau rarely fails to obtain fairly complete details of mine explosions in which more than one life is lost or in which a considerable amount of property is damaged; therefore, th data in these publications are relatively complete, especially as to mine explosions causing loss of more than one life.

The available information on mine fires is by no means as complete as on explosions, and scores of fires in coal and metal mines doubtless occur annually without the knowledge of the Bureau of Mines or even the State inspection forces. Mine fires occur almost daily in some coal mines, particularly at shot-firing time where some form of black blasting powder is used or where the coal fires spontaneously; and fires of electrical origin or those caused by open lights are by no means uncommon in metal mines.

A study of data available on mine explosions in the United States durin the past 11 fiscal years reveals an encouraging reduction in the frequency and severity of these disasters. The showing of the past fiscal year is especially encouraging, since it is the best record in the history of coal mining during a like period for at least 60 years.

The fact that there was not one major explosion for the past fiscal year in any of the approximately 6,000 coal mines of the United States is almost a miraculous performance. When it is considered that many of them are decidedly dangerous owing to explosive gas, that most of them have hazardous explosion conditions as to dust, and that more than half a millio persons are employed, producing nearly 400,000,000 tons of coal the record becomes even more impressive. This is especially noteworthy when comparison is made with what occurred 25 to 30 or more years ago in producing a somewha similar coal tonnage; for instance, in 1907, in producing about 478,000,000 tons of coal in the United States, there were 18 major explosion disasters with 918 fatalities. When this is contrasted with production of about 400,000,000 tons of coal in the past fiscal year without a major explosion disaster and with only 16 persons killed in minor explosions of gas or dust, one can almost believe that the age of miracles is at hand.

The 16 persons killed in the past fiscal year, all by minor explosions of gas or dust, is by far the lowest number of gas- and dust-explosion fatalities (major plus minor explosions) in any year in the history of coal

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ining in the United States in the past 60 years or more. The contrast is articularly great when compared with the 956 persons killed in major and inor explosions in the coal mines of the United States in 1907, showing as t does a reduction of more than 98 percent in fatalities from coal-mine ex-losions in the past fiscal year compared with the calendar year 1907.

Although safety men have a right to rejoice over a fine safety chievement in any period, particularly a record such as that of the coal ines of the United States during the last fiscal year as to explosion dis-sters, it is well to remember that "one swallow does not make a summer" nd that no one year's record justifies making sweeping conclusions and pecially very definite comparisons. However, conclusions may be drawn nd comparisons made when data for several years are considered, and even ere the record shows progress (and plenty of it) in the reduction of coal-ine explosions and of fatalities from them. In the period 1906 to 1910, nclusive, there were 84 major explosion disasters in United States coal ines, and an average annual fatality list of about 500; during the past 6 ears (1933-38, inclusive) there were 23 major explosion disasters with verage fatalities from them per year of less than 50, showing a reduction f 90 percent in fatalities from major explosions in the last 6 years as gainst the record of the 5-year period 1906 to 1910, the half decade just receding the date when the Federal Bureau of Mines began to function in try-ng to carry out the main purpose of the Congress of the United States in he organizing of the Bureau; this was to reduce the wholesale slaughter f workers from explosion disasters in United States coal mines. Unquestion-bly, that particular mandate has been handled effectively, and it now de-olves upon the mining people of the United States to take the necessary recautions (such as evidently were taken during the past fiscal year) to ake certain that the good record of the past 6 years shall be improved and hat there shall be no recession in safety effort or results.